CHEMISTRY IN OVERALLS

Industrial
Research
Laboratories of
Arthur D. Little
Inc.
July, 1918

Industrial Research Laboratories
Arthur D. Little, Inc.

DEDICATED TO INDUSTRIAL PROGRESS

THIS ORGANIZATION is the result of more than thirty years' successful experience in the application of science to industry. Ours has not been an easy task, because we have always tried to keep ahead of public opinion, rather than to follow it—and the pathmaker treads upon thorns. While others regarded the relations of chemistry to business as a subject for humor, like the legend of Darius Green and His Flying Machine, we insisted that industry cannot prosper in the long run without the aid of chemistry. We claimed that the manufacturer should know his materials as well as his men and, by means of science put into daily practice, hold every process under definite control, whether he make machinery, castings, textiles, paper or, it may almost be said, anything else. We not only preached this doctrine, but we practised it, and the developments of the past few years have justified us in our contention.

Our building, although lately completed, was planned for in detail long ago. We declared that it should be convenient of approach and yet removed from the turmoil and racket of heavy trucking and from all the thumping and disorder that so often offend the back doors of commerce and the front doors of industry. It should be provided with every facility for research and testing and it should be flooded with sunlight. It should have a high basement equipped with technical apparatus for making all sorts of things on a semi-commercial scale; a factory in miniature to meet the many and various problems that arise in the modern arts of production. Also, it must contain a chemical museum, to explain things. Here it is. And we bid visitors a cordial welcome.

Section of
General
Analytical
Laboratory

Section of Library devoted to our Reports

What We Do

TO answer this question in the abstract is easy: we solve problems in manufacture, we engage in industrial research and we make chemical analyses. We render service under contract with firms, corporations, municipalities and states, to report upon conditions and what to do to meet them, and we examine into and report upon the merits of new industrial projects. We manage corporations engaged in chemical manufacture for account of owners and trustees. We engage in chemical engineering on a major scale and not only develop methods and processes but design apparatus, construct works and then organize manufacture in them. We act as chemical advisors, in which we function in regard to materials in a manner similar to that of counselors-at-law in regard to contracts and measures. And we act as consultants.

To explain these things in detail is more difficult, but we shall try to make the subject interesting, for to our way of thinking it abounds in this very quality.

Let us begin with something that sounds dull at first, like chemical analysis, and observe whither it leads us.

Optical
Room

Ours is one of the leading analytical laboratories in the country and its scope is very wide. We make analyses by the many thousand, and have so developed our practice that we are now engaged in the preparation of a book which shall give our methods in detail for the benefit of the profession. Being organized for large quantities of work, it is surprising how speedily results are reached and with what constant accuracy. We undertake testing for manufacturing establishments in nearly every state in the Union, and owing to our large and competent staff and the broad experience of its members in a great variety of industries, we frequently provide chemical control of the materials and processes in the works at the same time.

Chemical control may sound theoretical, but it is, in effect, intensely practical and it applies where those who are unfamiliar with the subject would least expect it. For instance, if a man makes mowing machines he may not appear to need the help of a chemical engineer in his establishment, but if we inquire into the subject we shall find that he does. In fact, next to the design of his machine, the chemical features of his practice are of leading importance. Every unit of his product should be made of that very specific material which will provide the best and most enduring service at the lightest weight and the lowest cost. It requires a metallurgical chemist to select most of his materials in the first place and to hold them to quality afterwards. The question where the machine will wear out first or the location of any structional weakness is likely to be indicated in specially designed laboratory tests and the fault corrected before the machine is put upon the market. Every spring should be made of steel that maintains its resiliency, the knives should have and hold the best cutting edge that he can afford and the driving rods must be stiff without being brittle. These qualities are not regulated by the price paid for the steel; it often happens that the best is very cheap provided one knows just what to specify or to buy. Paint is another material which requires laboratory control to insure endurance, maximum covering power, quality of shade and proper cost, combined with protection against rust.

The structural characteristics of different steels and

Corner of
Fuel
Laboratory

the internal structure of paint films are subjects which, not many years ago, were wholly within the realm of pure theory. They have now become the very foundations of the best practice. Is it not obvious that the man who knows the real nature, and therefore the possibilities and limitations, of his materials is at least a neck ahead in the race of the one who judges quality by the price he pays or by the affirmations of a man whose interest lies in only making a single sale?

We hope we have made it clear that chemical analysis is merely one feature of the general application of the science to industry. Analysis is like the accounting department; it checks purchases and prevents mistakes, provided the figures it yields are interpreted and applied with full understanding of the uses of the materials, and it tells often what is going on inside of cupolas and all sorts of apparatus where nobody can look,— and even if he could he could not see. In certain pulp mills tests are made automatically and are so recorded. From these records graphs are made and from the graphs the manager knows exactly what is happening all the time, and he locates troubles *when they begin*, instead of after the damage has been done. But analysis alone, though it may lower costs, does not improve the product. For this purpose research is required. The two go hand in hand.

It may not seem clearly evident that a street railway system has much of a chemical side to it, and yet we do a great deal of work for street railways and they find it worth while. In the first place, they buy many tons of metal, both ferrous and non-ferrous. Here the metallurgical chemist makes specifications for that which will best serve each purpose, and deliveries are tested. Paints and varnishes cut a larger figure than with the mowing machine man. Important savings are made by buying supplies such as lubricants, boiler compounds, soap and cleansing powders according to actual needs, under specification and in bulk. Chemical control is needed in the purchase of railway supplies all along the line, and it takes experience as well as study to maintain it. This would seem to be self-evident and unnecessary to say, nevertheless we can point out utterly absurd losses in great organizations that are

Titration Room

otherwise well managed, all for lack of this needed and specialized form of control.

The purchase of coal by heat units instead of by name and weight, the analysis of flue gases to tell how much coal is wasted in firing and the buying of lubricants on specification instead of by prejudice or favor are economies that would seem too patent to argue about if it were not for the fact that the old, expensive method of buying by guess and talking is the more current one even to this day.

No one would think at first glance that a dry goods merchant needed the chemist's aid, and yet here is what we do for dry goods and department stores in our textile laboratory. We determine the actual fibre content of samples furnished. This avoids errors in the quality of goods purchased and provides the only proper basis for the guaranty that goods are what they are represented to be. Guaranties based upon guesses are expensive. We determine the strength and wearing qualities of fabrics and we test the resistance of dyes to light, bleach, mud-stains and washing. We analyze hosiery, for instance, in regard to structure, content, wear and general merit, as definitely as we would a rod of steel. Even in the matter of supplies, such as paper, stationery, twine, soap, polish, etc., we make specifications that result in remarkable savings.

A bank is hardly a chemical institution and yet we are frequently called upon by bankers and investment houses for help. A manufacturer of an unfamiliar product may be doing well but increasing his obligations in a measure to arouse the concern of the careful banker. A confidential report from us on what the manufacturer does, what his product is and whether his processes are economical and adequate posts the banker on the very features of his depositor's business that he desires to understand. It enables him to judge as to the right line of credit, and often clears away doubts that have restricted legitimate and desirable loans. Again some one will come along with an invention all patented and the patents passed upon by eminent counsel. It looks like the proverbial gold mine with an engaging prospectus, a financial plan with provision for working capital and with sales practically guaranteed. But the process, which seems to be mechanical,

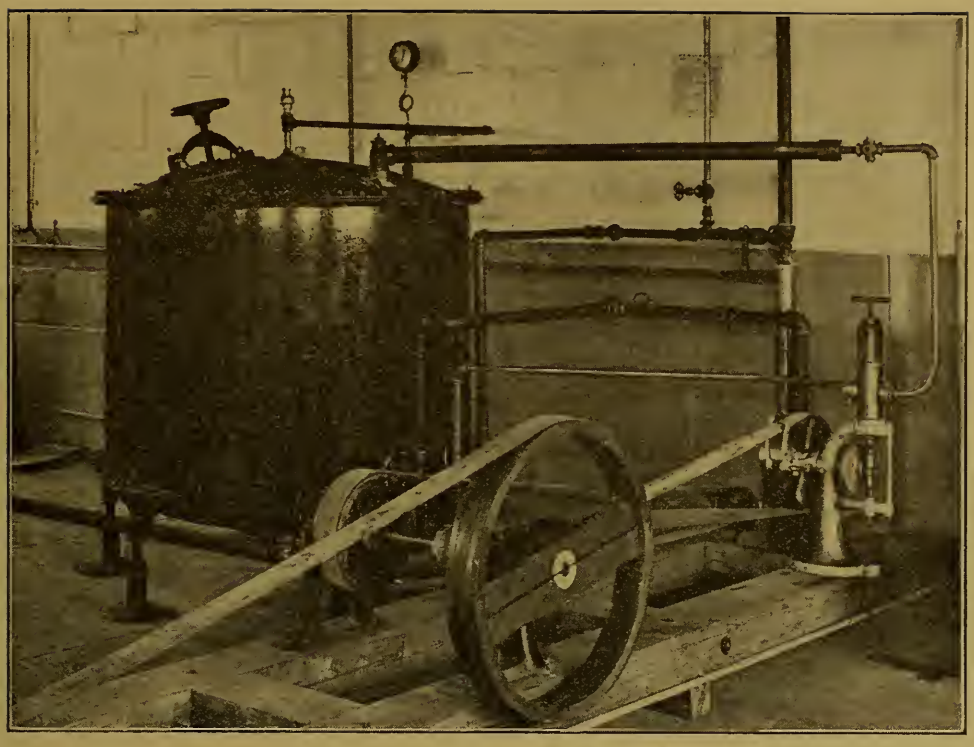
One of the Special Laboratories with Office

involves principles of physics and chemistry which the wisest business man is almost certain to miss unless he is thoroughly familiar with the scientific basis of the art involved. Now unless every step in manufacture is developed through factory as well as laboratory research and tests, the proposition may be fairly bristling with otherwise invisible chances of failure.

"State of the Art" searches, in which we have long specialized, prove no less useful to banking and investment houses than to manufacturers. These provide a careful study of prospective as well as present markets for materials, compare available methods of production and, by a diligent scrutiny of the progress of applied science both here and abroad, disclose dangers which threaten long before they are felt. We also point out where extensions of sales are warranted.

From a banking standpoint it would appear that a manufacturer should himself see to it that his establishment is kept up to date in the matter of raw materials, processes and use of wastes, but we regret to say that very often, and by far too often for the welfare of American industry, he does not. Time and again, if he has a good thing, he lets it go at that — while somebody else, somewhere else, works out a shorter or cheaper method or a better product, and he is left stranded. Then the creditors form a committee and the president of the bank explains to the directors that the failure is due to cut-throat competition, — while the competitors are getting rich! The trouble was that the manufacturer had failed to learn that the most practical thing in the world today is science. Now it always has given, and it probably always will give a man a financial black eye to say of him that he is an impractical theorist, and experience teaches that the impractical theorist is a dangerous borrower no matter how honest he may be. But the manufacturer who is not scientific of disposition and who conducts his business without competent control of his materials and processes is unable to keep informed of the march of progress and by this very fault invites hazards that are bound to affect his credit. He, too, is a dangerous borrower. Information of this sort is not available from mercantile agencies or credit bureaus.

Balance Room



Semi-Commercial Scale Apparatus

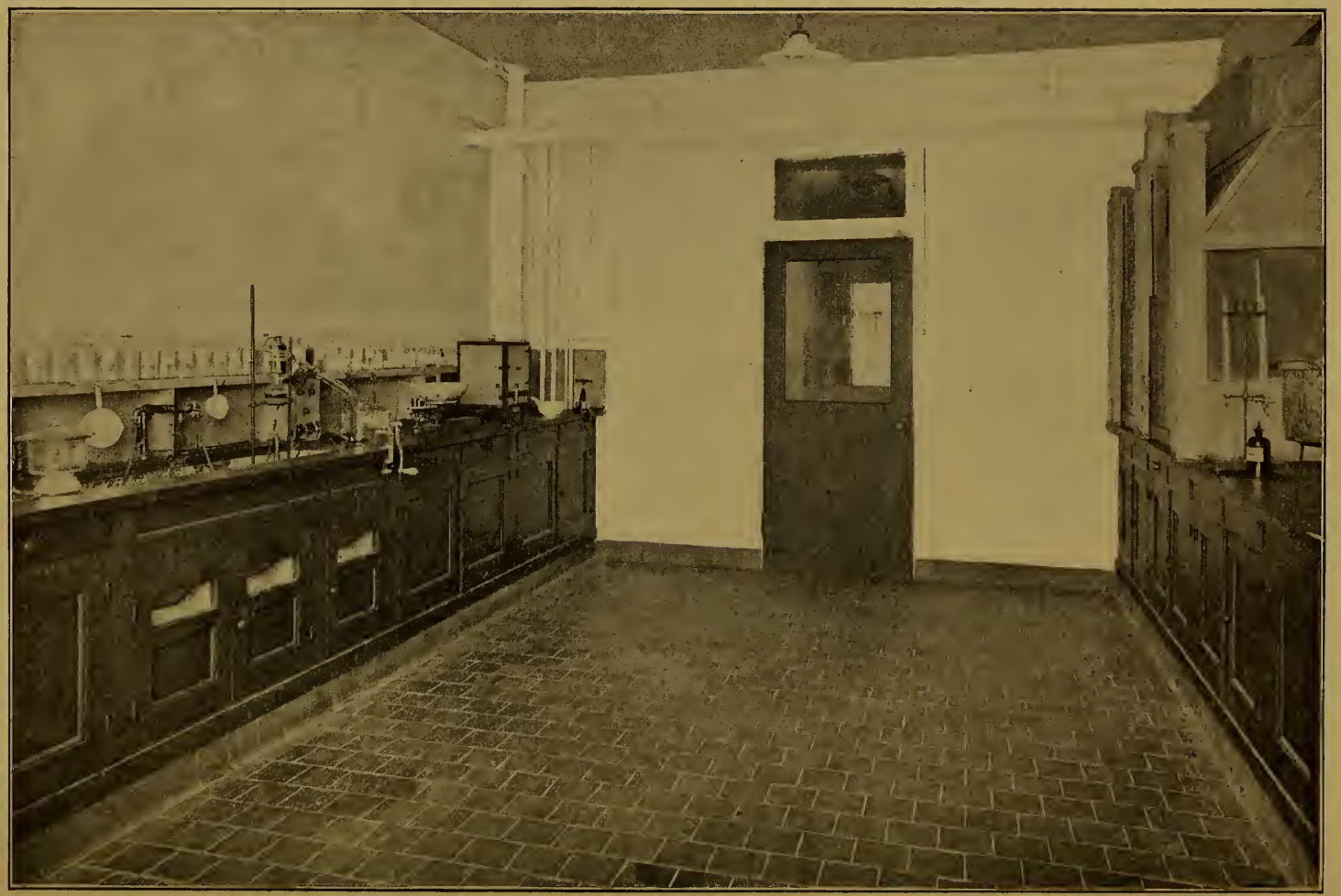
Research

THIS is our leading business. It consists in finding out how to do things and, in the industrial field, how to do them profitably. And it includes invention. Some of the great manufacturing concerns now spend millions and many other corporations spend hundreds of thousands of dollars each, every year on their research laboratories, to find out things. Our establishment is a research laboratory at large to American industry.

So much of our work is of a confidential nature that, while we are now engaged almost to the limit of capacity, we have to go back a number of years for most of the examples which we are at liberty to discuss. Some of the fruits of our research during the past year are of greater general interest than any that we shall mention, but they are not for publication as yet. What follows is given to indicate the scope and something of the nature of past performances.

The chrome tanning of leather had been undertaken abroad by cumbersome and ineffective methods. A far

Special
Problems
Laboratory



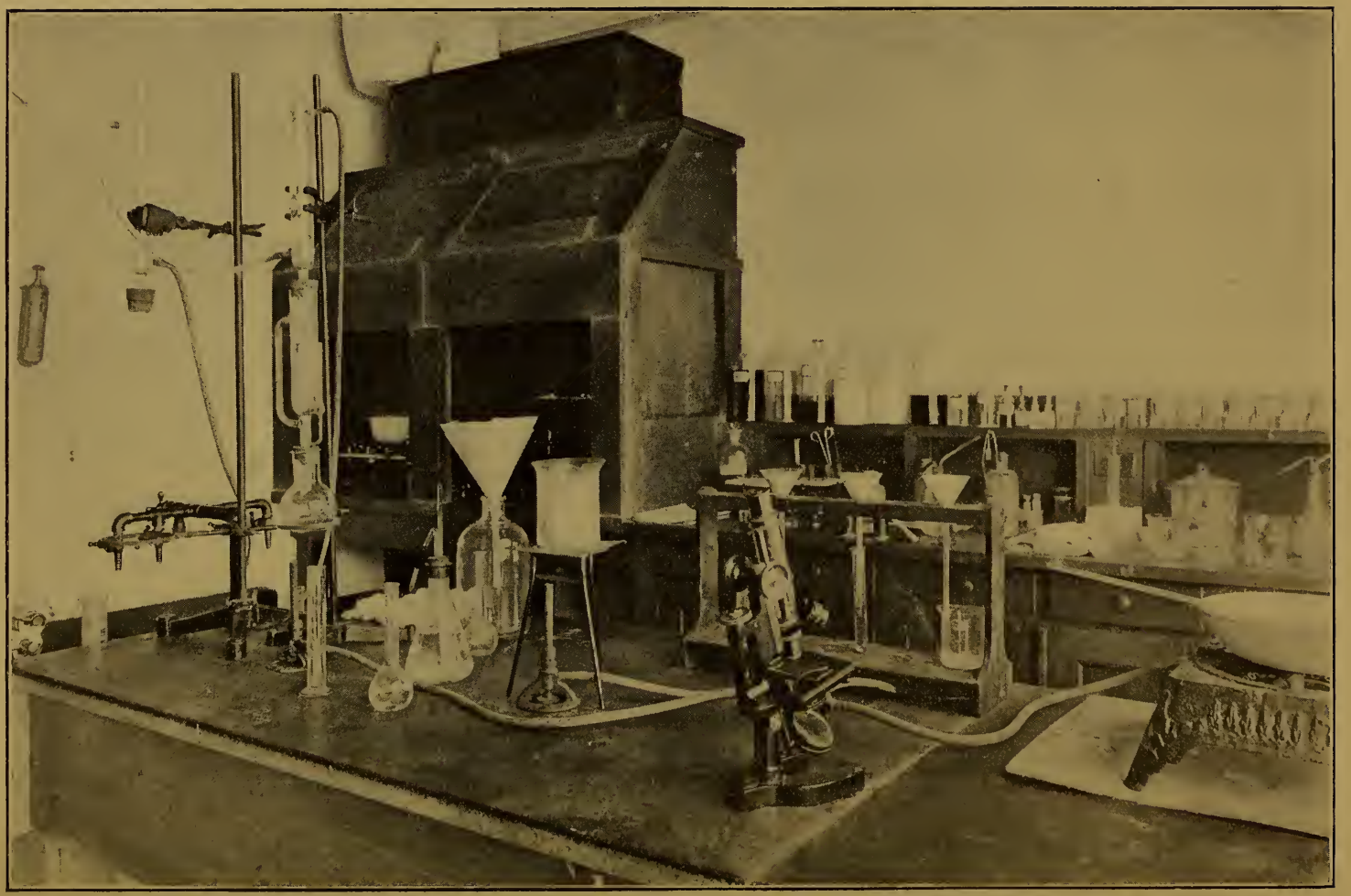
better process had been worked out and patented in America but it was generally overlooked and forgotten by the tanners. We studied it, demonstrated its entire practicability, extended its scope by some supplementary inventions of our own, and we tanned skins in the factories before skeptical tanners who became so thoroughly converted that a few years later ninety-five per cent of all the upper leather in this country was chrome tanned.

At the time when street railway power plants were mostly hay burners we began the study of applied electrochemistry. We brought to this country from England and put into operation the first commercial process for the electrical production of bleaching agents. A few years later our reports provided the incentive for the erection of the first plant in America for the production of chlorine and caustic soda by the electrolysis of common salt. Another plant, and a spectacularly successful one, was built to operate a process invented by us for the electrolytic production of chlorate of potash. We are still studying electrochemistry all the way from aluminium through nitrogen fixation clear down to zinc.

From the beginning of our organization we have been active workers in the chemistry of cellulose. This is nature's great structural material. It is the essential component of the cell walls of plants and as such the basis of all plant tissues. So its properties are of interest and importance to the lumberman, the maker of cordage, the spinners and weavers of cotton, the workers in flax, hemp, jute and ramie, the pulp and paper makers and to all those whose business it is to utilize this remarkable material that still remains the product of nature's secret laboratory.

This is only a hint of the bewildering possibilities and actualities of cellulose. Things happen when you begin to treat it chemically. It takes kindly to nitric acid and becomes gun-cotton and smokeless powder,— after which it becomes less kindly. Less highly nitrated it functions as soluble cotton, collodion, celluloid, and it appears in lacquers, artificial leathers and a host of other things. Treated with caustic soda and carbon bisulphide it is transformed into viscose and later comes upon the market as artificial silk, of which twenty million pounds were produced in 1913.

Portion of
Textile
Laboratory



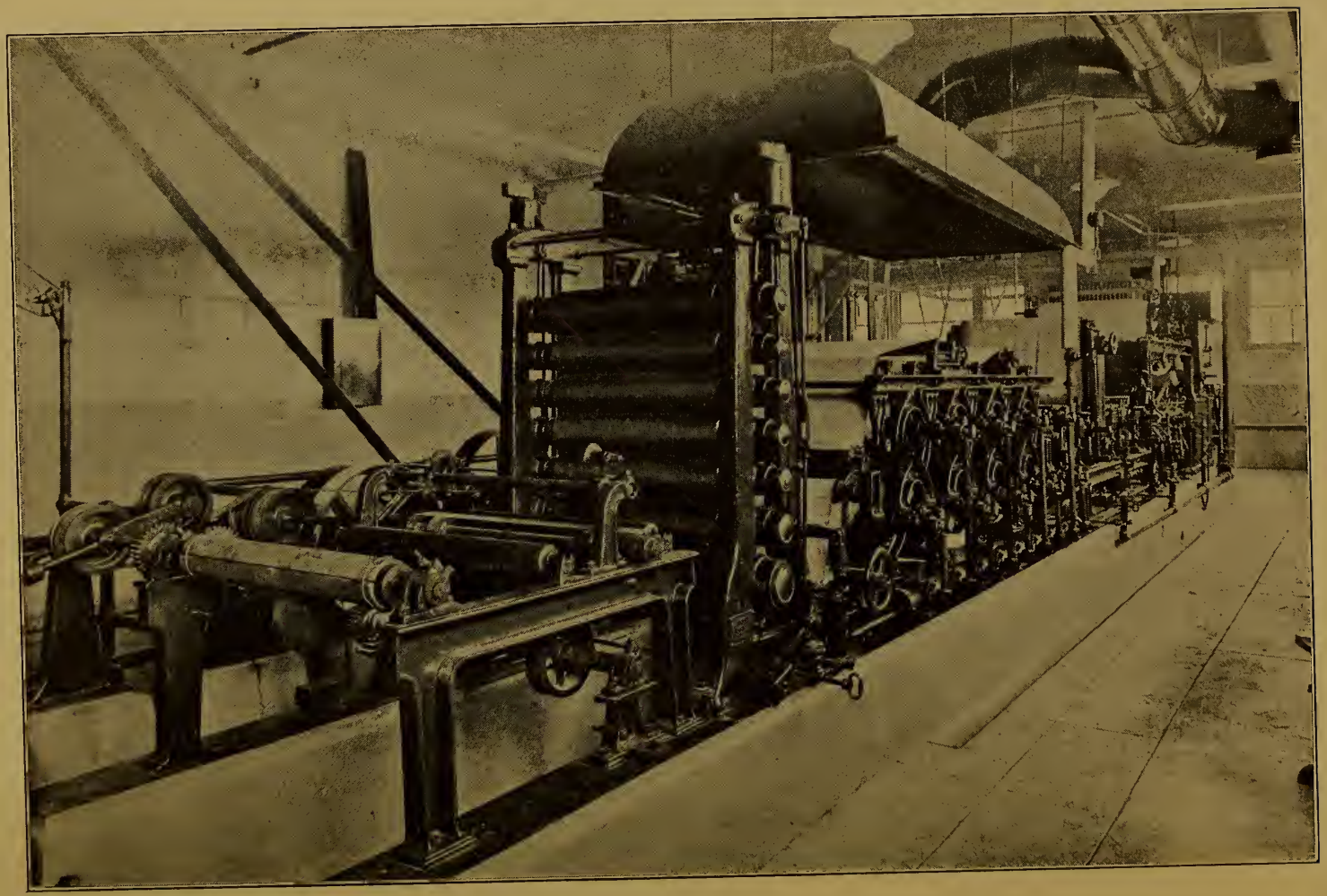
Acetic anhydride transforms cellulose into cellulose acetate, a first cousin of the nitrate but less temperamental, being non-explosive and harmless as a paper doll. From it we have made artificial bristles, a superior artificial silk, non-inflammable films for moving pictures, wind shields for aviators and dopes for aeroplane wings. We have found new solvents for the material and invented methods for its production in fibrous form. Just now cellulose acetate is a war commodity, but with the release of raw materials following a righteous peace there will come a lively flourish in the cellulose acetate industry. Meanwhile there is hardly an industrial application of cellulose or its products with which we are not identified.

Chemistry and capital together constitute perhaps the most effective agency for the comprehensive and systematic development of a country's resources, and this broader application of the science has long appealed to us. Our studies in the tropics, in Cuba, Hawaii, etc., and of the industrial resources of the South were forerunners of the organization of the Natural Resources Survey of Canada which we carried forward under the auspices of the Canadian Pacific Railway to the point where the work was taken over by the Canadian Government.

If zymo-technology is a word that twists the tongue uncomfortably, let us call it fermenting, which will indicate the subject. This is an enormous field, quite aside from beer and wine, and there are oceans of work to be done in it. There are a great number of yeasts and bacilli that cause fermentation with a great variety of products as the result and they are, like fire, good servants but bad masters. When the desired culture is secured for a given purpose and its life and habits are studied and mastered, ideal manufacturing conditions may be attained. They work while you sleep and they live in a tub. From an industrial standpoint the great field of bacteriological chemistry is full of interest and of promise.

We have helped to develop the production of alcohol from wood waste such as sawdust, etc., and from other materials having a basis of cellulose and we have done effective work in the opposite direction in the way of preventing rot, fermentation, mould, decay and the like.

Experimental Paper Mill, The Paper Machine with Driers and Calenders



We have done successful work in the sterilization of water and in its treatment for various purposes from feeding boilers to table use and also in the treatment and disposal of sewage and factory effluents. We have been able to save many thousand dollars for our clients by specifying effective boiler compounds for them after a study of local waters and avoiding for them the purchase of useless nostrums at preposterous prices. We recall one instance of ordinary black-strap molasses sold for this purpose at eighty cents a gallon in barrel lots.

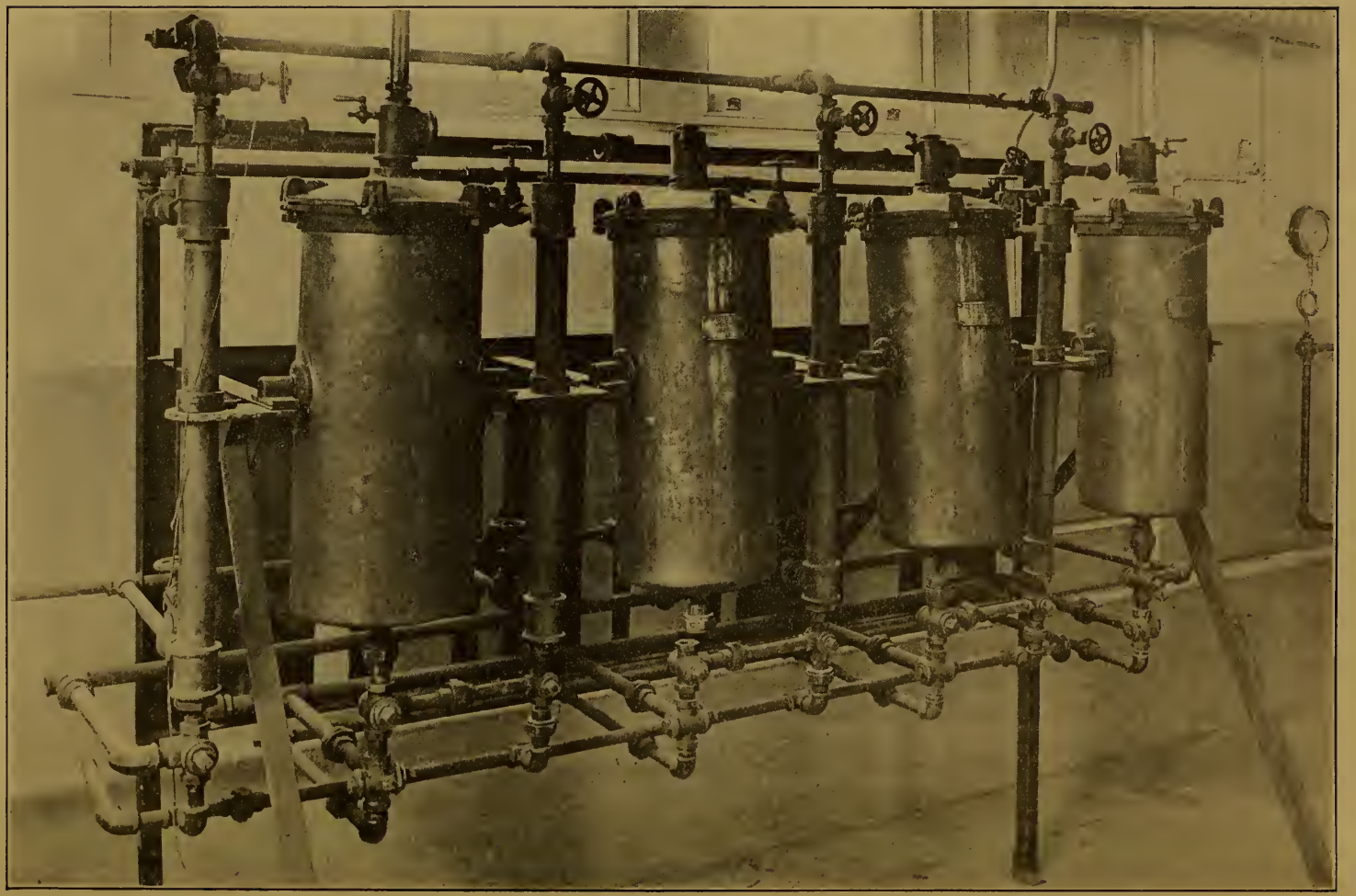
Skim milk is chiefly casein and, while it is a food rich in protein, it was formerly fed to the pigs or thrown away. Chemical research brought out its value in paper sizing, in making water-soluble paints for interior use and for many other purposes. The casein industry had started abroad but was untouched in this country until we were retained to undertake its technical development, which we did. And that was its beginning in America.

Another use for skim milk in which the initial invention was developed to successful manufacturing procedure in our establishment we told about in the July, 1918, number of *The Little Journal*, a house organ which we publish occasionally and send to any one that asks for it. This consists, under a patented process, of emulsifying cocoanut oil and skim milk in water and then stabilizing them so that the product has substantially the same food qualities as milk and cream and it looks and tastes like milk and cream. The skim milk may be shipped dried, and no cow is needed within ten thousand miles.

Binder twine, used in the harvest fields for binding sheaves of wheat and other grains, was formerly often consumed by crickets, leaving the sheaves unbound. We were called upon to solve the cricketal problem thus presented. This required elaborate entomological research, the discovery why the crickets consumed the twine and, following this, an effective means of discouraging them from their attacks.

Again we were required to develop a waterproof paper that would not tear, which is now manufactured on a considerable scale. Our contributions to the paper industry have been many and extend over the entire period of

Diffusion Battery, Semi-Commercial Size

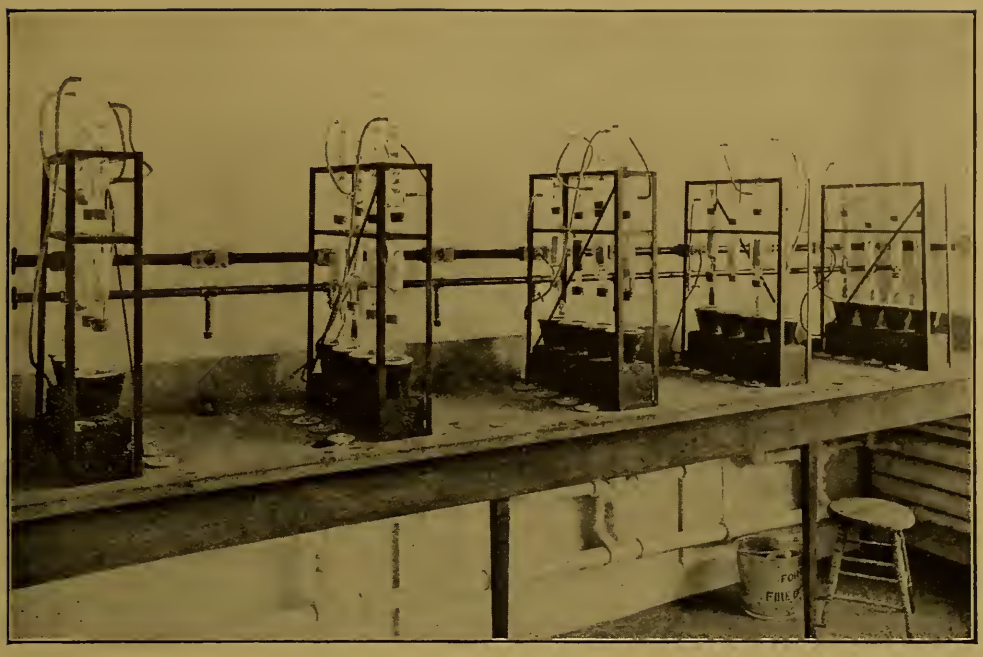


our history. The question of where future supplies of paper are to come from is a pressing one and in our complete experimental pulp and paper mill we have tested out a large number of different materials of which some are full of promise. We have been important factors in the development of the sulphite pulp industry especially and our connections with the paper industry are very extensive. An interesting undertaking which we described in the April, 1918, issue of *The Little Journal* was the production of a certain kind of paper felt from bagasse to function under the Eckart patents for covering the young sprouts of sugar cane and thus avoiding the growth of weeds in Hawaii. It increases the yield over 25 per cent and cuts down the labor costs from 50 to 70 per cent by eliminating the necessity of repeated weedings. We are now putting up a mill in Hawaii to make this paper felt.

We have made extensive researches into the lumbering industry and the results of our studies of the actual and proved possibilities of the long leaf pine cut in particular bring out the amazing fact that the industrial value of a full grown pine tree is no less than five times what we get from it. If, of all the yellow pine cut, the entire trees were used, not only as theoretical science teaches but according to known and proved methods of applied science, there would be added to the estate of the American people *every day*, 40,000 tons of paper, 3,000 tons of rosin, 300,000 gallons of turpentine and 600,000 gallons of ethyl or grain alcohol together with the fuel for these industries besides the lumber we get as it is. Of course, this would require a heavy expenditure of capital and a large amount of labor, but the facts remain.

It is our firm belief that thus far science has only scratched the surface of industry. The great rewards await those who have the faith and courage to plough deep.

Complete Rectifying Still 25 gal. Capacity



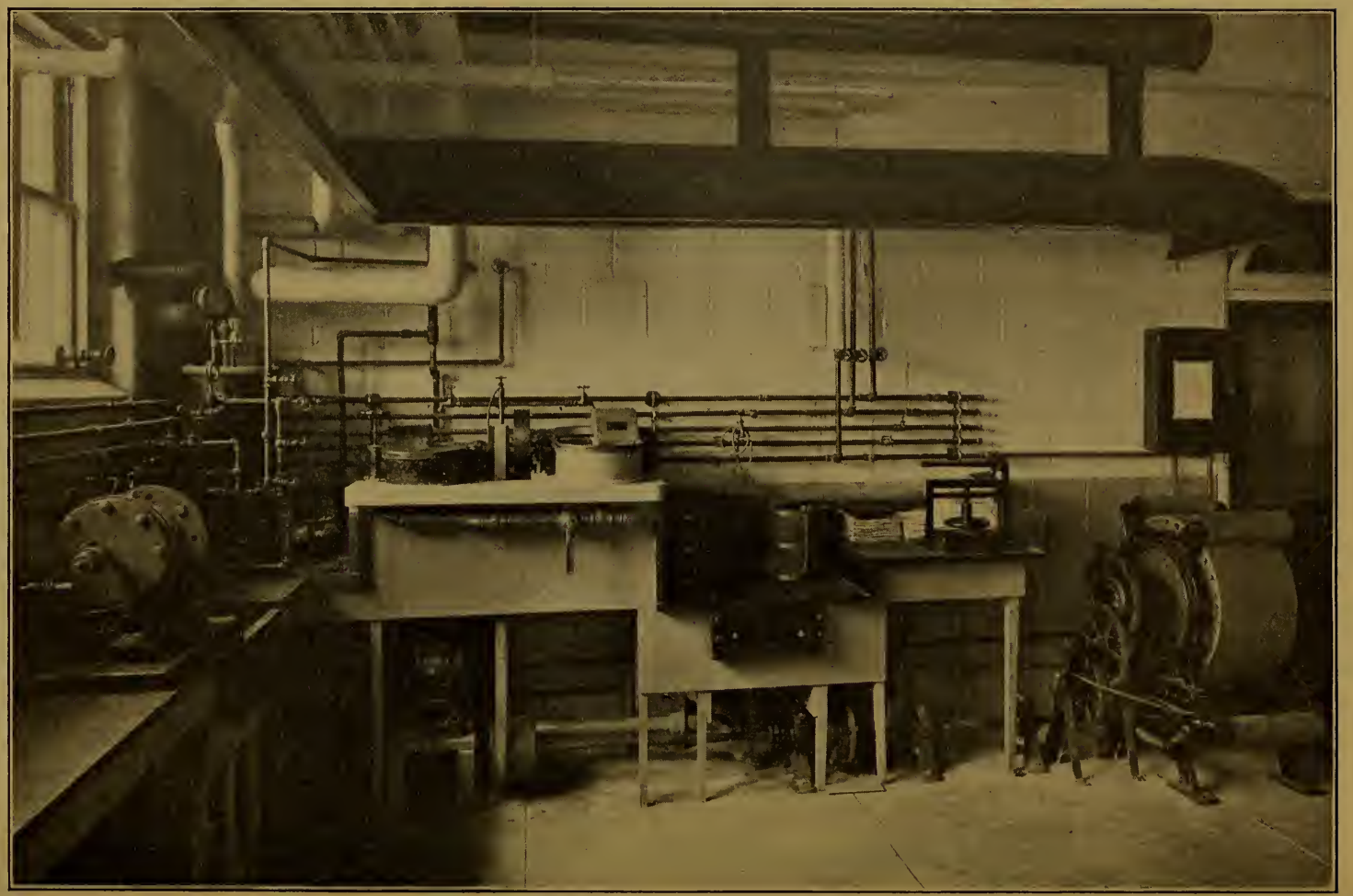
Part of Extraction Room

How We Do It

WE are proud to say that twenty of our staff are in war service. Good chemists are generally admitted to be hard to get these days, but we have been able to keep our ranks full of able and competent men and women. So the work goes right on in increasing proportions and with no decrease in precision or the achievement of results. The reason for this is our carefully planned organization and the long experience of the men at the top. We hope to get our old members back when the war is over and to keep them busy, for there is more than enough work for us all to do.

We have a Commercial Department in charge of a chemist of broad experience in business and technology who takes care of initial correspondence and interviews. He is kept pretty busy,— and he has never been known to complain of the tediousness of his occupation. The batch of problems that he brings before the staff every day are of the most miscellaneous sort. A laundryman may want to determine where responsibility lies for damaged goods. A manufacturer of cutlery wants a special steel for a special

Laboratory Scale Paper Mill "The Baby Mill"

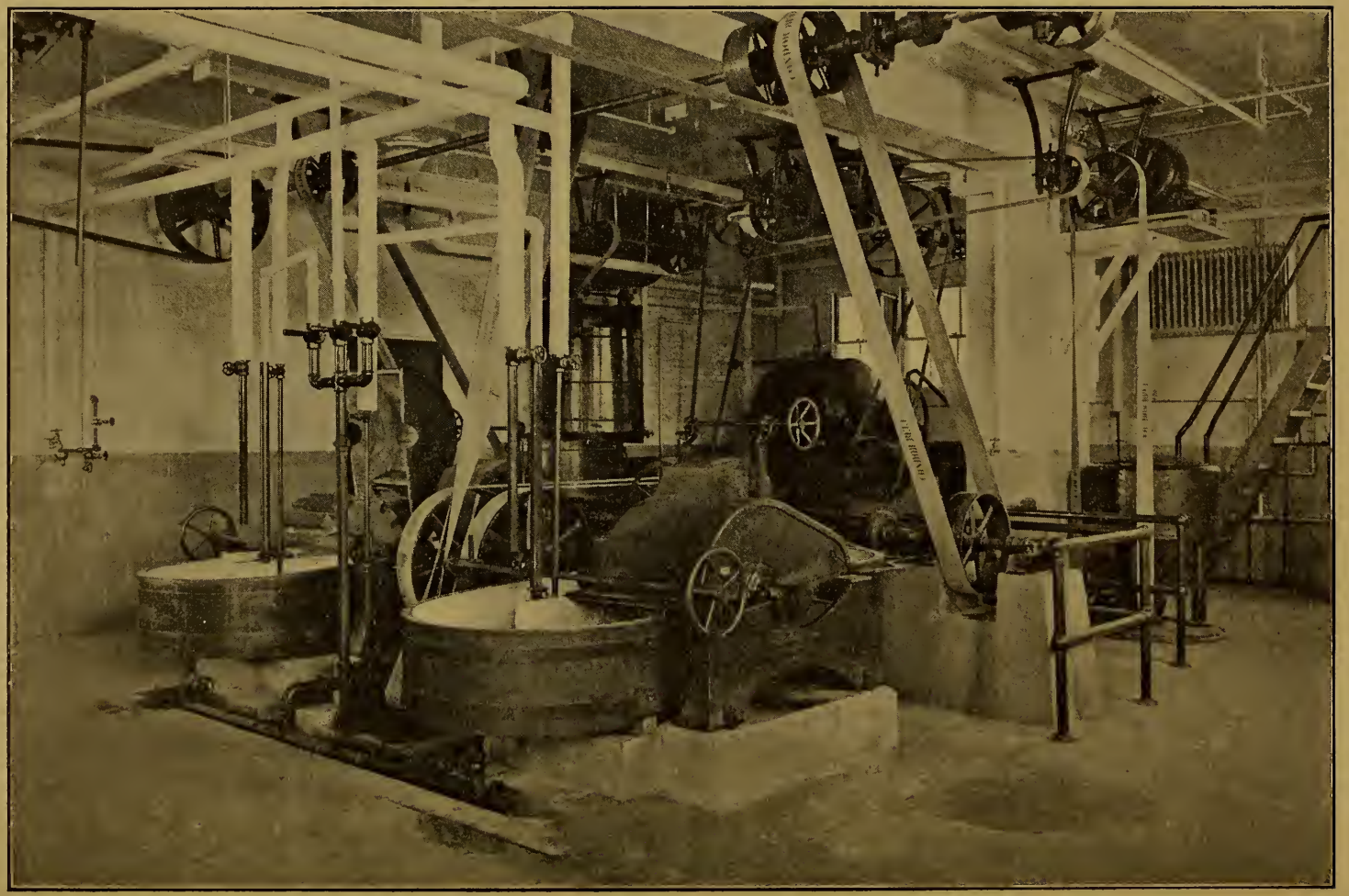


purpose. An automobile maker has trouble with his paint and another with his crank shafts or piston heads. A candy maker wants a better chocolate coating and a baker wants a method of procedure with wheat substitutes. A cargo of corn meal must be tested as to oil and moisture content which would be a simple proposition except for the fact that it involves upwards of two hundred and fifty separate parcels calling for that number of analyses — and the ship wants to sail next Monday. A bank may want paper or ink tested as to permanency for records. These, together with a lot of factory and miscellaneous tests, will indicate an ordinary day's grist that comes in.

All proposals as accepted go into the hands of the service manager. Analyses pass on to the third floor and there go through the regular routine, surrounded by every check and safeguard to insure strict accuracy. Special problems are referred to the department familiar with the particular work involved, while major problems are likely to call for a conference of the staff; and despite the many years of working together, a conference of this sort still brings out an interesting variety in methods of attack.

As soon as a member of the staff has a major problem in hand he turns naturally to the library where he may spend several days going over the literature of the subject. The extent and convenient arrangement of our library may be gathered from the isometric diagram shown on page 30. Here are over thirty thousand sources of information indexed by means of over one hundred thousand cards. Scientific literature is to be found only in lesser part in treatises; the greater detail and more recent advances being in periodicals which print the original papers, usually, of course, in the language of the country of their origin. The library contains a great wealth of the leading scientific journals of the world and it maintains close relations with other special and institutional libraries. In addition to books, journals and monographs, there are immediately available the bound manuscript and typewritten records of all the work done by the firms of Griffin & Little, Little & Walker, A. D. Little and Arthur D. Little, Inc. since 1886, when the original firm of Griffin & Little was founded. These contain thousands of technical reports, special reports

Experimental Paper Mill Beaters, Bleach Mixing Tanks, Rotary Digester



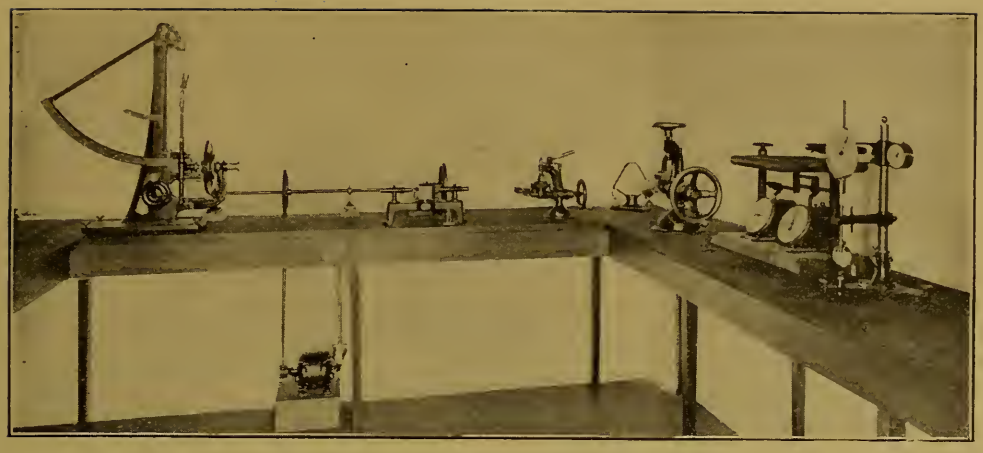
with laboratory notes, experimental and other data, and fill fourteen large shelves of bound volumes.

Our library has been the subject of a number of articles in library journals and is regarded by librarians as a model of its kind. Books are only useful when their contents are available, and the system of indexing enables authorized persons to have nearly the entire literature of a subject placed before them shortly after proper advice to the librarian.

The service manager is in close and constant touch with all work in hand and informs clients who want to know how their affairs are progressing. As soon as laboratory studies have reached a satisfactory conclusion we either equip apparatus to make a semi-commercial test in our own establishment, or a try-out is made in the works of the client under the supervision of one of our chemical engineers. Often special apparatus must be designed for which we have the necessary draughting room and experience in the work.

There is one kind of business that we do not invite and that is research to avoid the incidence of sound patents taken out by legitimate inventors. On the other hand it is our constant effort to improve and shorten processes, to lower costs of production and to find technical uses for waste materials. We believe in the patent system and we take out such letters for our clients when we think they will provide added protection.

Room
Where
Current
Samples
are Stored

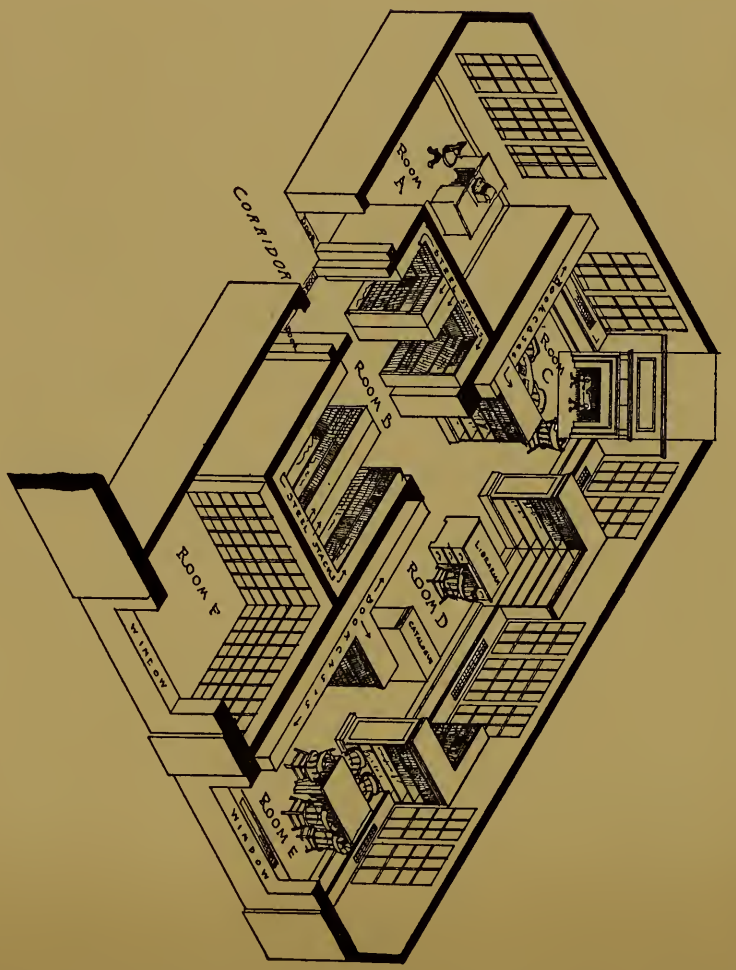


Portion of Paper-Testing Laboratory

What It Costs

IT does not cost anything to find out what our charges are for a given amount of work. They are based upon the time of the men engaged and the amount and nature of apparatus involved. Analyses and tests, if made singly, naturally cost more than if made in series under contract. We work, in short, by the day, the month and the year. The solution of problems in research cannot be foretold as to time any more than as to results, else they would not be problems, although the amount of work to be put upon a task may be definitely fixed. Sometimes a time limit is set against appropriations for the purpose and when results are reached earlier than expected, only part of the appropriation is required. Again, such appropriations may not provide for the completion of work undertaken. Some clients request us to go ahead with a problem until a positive or negative result is definitely reached. Then the charges are the same as though we had been able to estimate them beforehand. Other clients engage us by the year for work on such problems as they may assign; and of these there are always enough in a large, live organization to keep a chemical laboratory busy. Still others retain us to supervise the chemical side of their business either on a per diem basis or by the year. We are always prepared, on being made acquainted with the details of a problem, to submit a plan for work on a basis which we believe will be to the greatest advantage of the inquirer.

Section of Library



Isometric Diagram of Library

Section of Museum

The Chemical Museum

THIS is on the first floor and is open to the public. It is designed to show what has been and can be done in applied chemistry and is arranged to show, as far as possible, the relations of raw materials to finished products. We have not room to tell of more than a few of the things exhibited but hope that what follows will give an intimation of its purpose.

As one enters he observes in the first case samples of cellulose acetate with moulded articles made from it together with varnishes, lacquers, artificial silk, bristles and coated wire for electrical apparatus, all five of which originated in our laboratory. In another case is a large exhibit of other classes of artificial silks in all stages of manufacture, including some fabrics of beautiful design. Elsewhere are specimens of artificial fur which was worked out for a client by our textile laboratory and is on the market.

There are experimental products of cotton stalk fibre and a large exhibit of the results of research in the industrial uses of straw. This is full of interest and shows the wealth that is wasted when straw is burned after threshing.

There are straw lumber, straw tar and tar products, beautiful writing paper from flax straw, slow-burning fuel from wheat straw for domestic and industrial uses and a whole shelf full of other things. There are also illuminated photo-micrographs of sections of various straws showing what an excellent engineer nature is in the use of spiral tubing for lifting fluids under low pressure. Elsewhere are Professor Worthington's photo-micrographs that tell the remarkable things that happen to a drop of mercury when it falls three inches upon a smooth glass plate.

Another exhibit is chemical paper pulp made from a great variety of woods and other materials and cloths made of paper. Here, too, is our soldiers' vest and a window envelope of one piece which we lately worked out for a client. There are rare earths and their products, including gas mantles in every stage, and a large display of cottonseed products. Then there are a series of abrasives and refractory materials, leathers tanned by various processes, optical glasses, gums, waxes, examples of photo-dyeing, shales, rare chemicals and those of historic value; in short, as we said at the beginning, we have not space to tell of all the things that are there and for the same reason we cannot mention the many donors of these things to whom we are indebted. In preparation we have a department designed for the benefit of purchasing agents with an instructive display of "chemical fakes." Finally there are historic books of which one is the original Paris, 1789, edition of "Traité Éleméntaire de Chimie par M. Lavoisier,"—who was the master of us all.

ARTHUR D. LITTLE, INC.

30 Charles River Road
Cambridge, Mass.

Beacon Hill
from the
Laboratory

PRESS OF THE MURRAY PRINTING COMPANY, CAMBRIDGE, MASS.